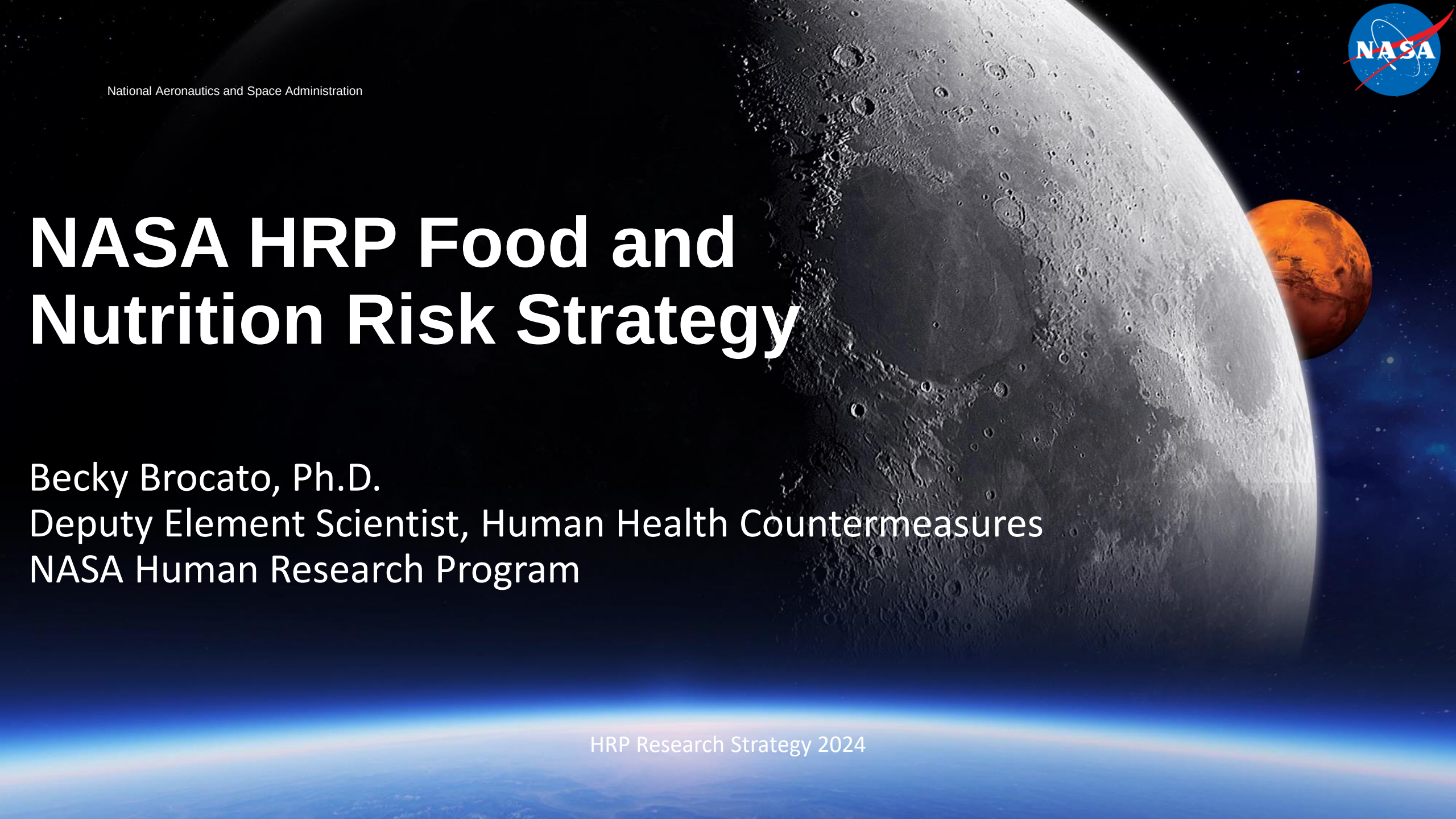


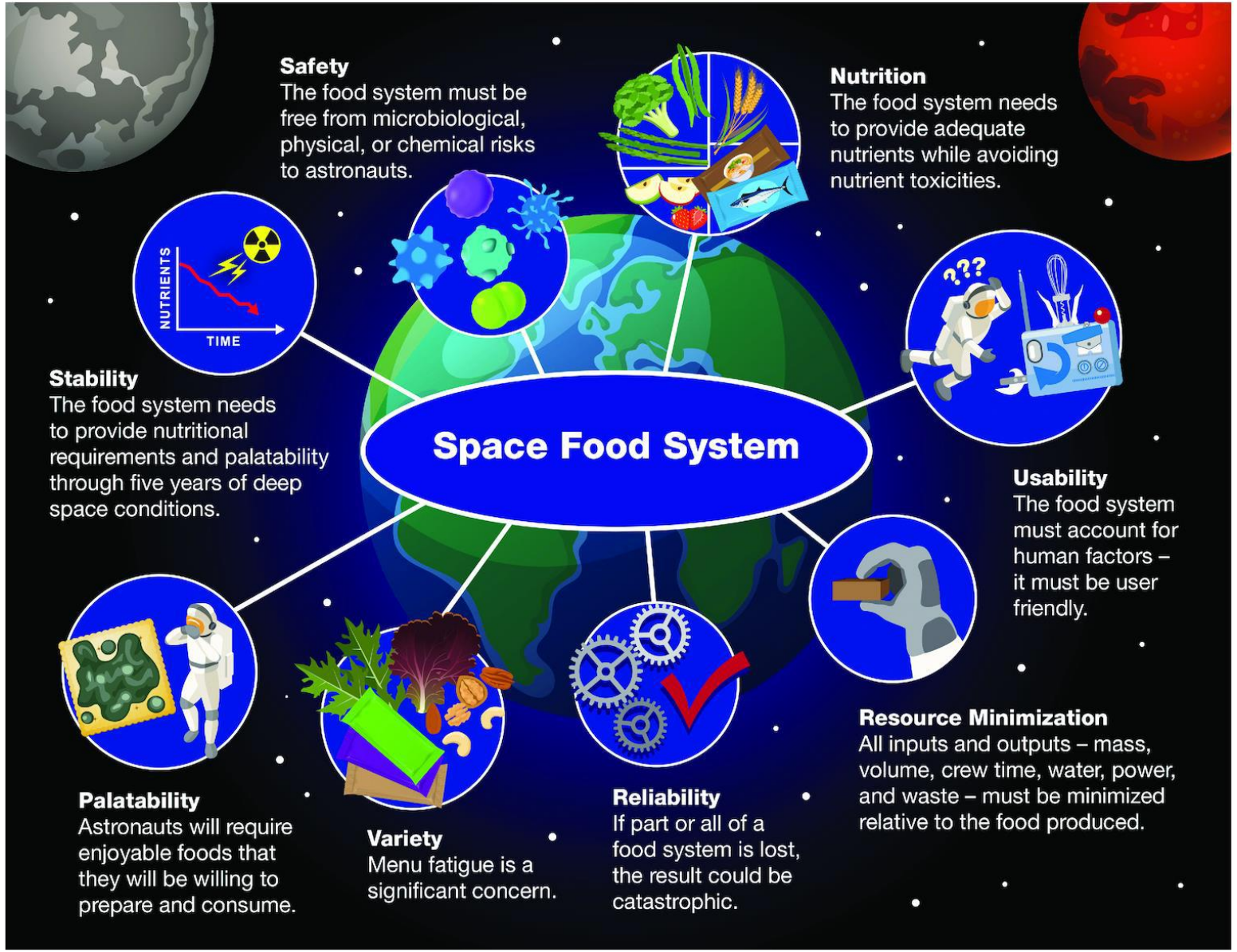
National Aeronautics and Space Administration

NASA HRP Food and Nutrition Risk Strategy

Becky Brocato, Ph.D.
Deputy Element Scientist, Human Health Countermeasures
NASA Human Research Program

HRP Research Strategy 2024

Considerations of a Space Food System



Douglas, *et al*. 2020, *J Nutr*

Current ISS Food System

8 Standard Categories –
feeds a crew of three for 7-9 days

1. Breakfast
2. Rehydratable Meats
3. Meat and Fish
4. Side Dishes
5. Vegetables and Soups
6. Fruits and Nuts
7. Desserts and Snacks
8. Beverages
9. Condiments
10. Snack/nutrition bars

Supplemental Categories

11. Personal Preference
12. Coffee/Tea Preference
13. Fresh foods (periodic)

- Switch from preference to standard menu in 2008
- Increase in variety (from 130 to 200 items)
- Reduction in sodium (from ~5300 to 3300 mg/day)

Food Prep Equipment

Hot metered water
Ambient water
Food warmer
Small chiller

Ascent and descent

No rehydration or heating
Only water/ready to eat foods
Food mass limit

Slide courtesy of G. Douglas, NASA Space Food Systems Laboratory

ISS Food Types/Sources

Freeze-dried Foods

Thermostabilized Foods

Natural Form and Low Moisture Foods

Irradiated Foods

Beverages

ISS Shelf-Stable Food System
80% Standard Foods, 20% Preference Foods

Limited fresh fruits, veggies, semi-shelf stable foods by resupply vehicles

VEG-04 Mizuna Mustard

PH-04 Hatch Peppers

Limited Crop Production on ISS

Pictures courtesy of G. Douglas and G. Massa, NASA

Challenges for Exploration Missions

ISS Shelf-Stable Food System (approximately 2-3 year shelf-life)

Limited fresh fruits, veggies, semi-shelf stable foods by resupply vehicles

Limited Crop Production on ISS (Tech demos)

Food System is a large mass driver
↑ Mass/Volume Constraints

High tempo EVAs, meeting nutritional requirements for energy expenditures

Red Risk

Food System is a large mass driver
↑ Mass/Volume Constraints

No resupply or crew preference

Nutrient temperature stability for a 5-year shelf-life unknown

Red Risk

HRP Food and Nutrition Risk Approach Plan

FN-101: Determine the nutritional requirements that would maintain health and performance for DRMs.

FN-102: Determine the nutrient content, safety, and acceptability of the spaceflight food system (specific to each DRM and associated vehicle constraints).

FN-201: Develop countermeasures either within the food system (i.e. variety, process improvements, crop growth, etc.) or in addition to (i.e. supplementation, etc.) to mitigate decrements in nutrition status, mitigate DRM impacts on health and performance outcomes, and/or risks to food safety, stability, and/or acceptability.

FN-301: Validate an integrated CM in flight.

DRM=Design Reference Mission

https://humanresearchroadmap.nasa.gov/

HERA

scientific reports

OPEN

Impact of diet on human nutrition, immune response, gut microbiome, and cognition in an isolated and confined mission environment

Grace L. Douglas[1,9✉], Diane DeKerlegand[2], Holly Dlouhy[3], Nathan Dumont-Leblond[4], Eden Fields[2], Martina Heer[5], Stephanie Krieger[3], Satish Mehta[2], Bridgette V. Rooney[6], Manolito G. Torralba[7], Sara E. Whiting[3], Brian Crucian[1,9], Hernan Lorenzi[7,9], Scott M. Smith[1,9], Millennia Young[1,9] & Sara R. Zwart[8,9]

20ft Chamber

HLS menu testing given exploration mission constraints

MCO CHAPEA

Mars analog characterizing crew health and performance (risk/resource trades)

ISS

Nutritional Status Assessment
Biochemical Profile
Pro K
Standard Measures

The Nutritional Status of Astronauts Is Altered after Long-Term Space Flight Aboard the International Space Station[1]

Iron status and its relations with oxidative damage and bone loss during long-duration space flight on the International Space Station

Longitudinal metabolomic profiles reveal sex-specific adjustments to long-duration spaceflight and return to Earth

Dietary acid load and bone turnover during long-duration spaceflight and bed rest

Nutritional biochemistry of spaceflight

Fifty years of human space travel: implications for bone and calcium research

S M Smith[1], S A Abrams, J E Davis-Street, M Heer, K O O'Brien, M E Wastney, S R Zwart

HRP Food and Nutrition Risk Approach Plan

FN-101: Determine the nutritional requirements that would maintain health and performance for DRMs.

FN-102: Determine the nutrient content, safety, and acceptability of the spaceflight food system (specific to each DRM and associated vehicle constraints).

FN-201: Develop countermeasures either within the food system (i.e. variety, process improvements, crop growth, etc.) or in addition to (i.e. supplementation, etc.) to mitigate decrements in nutrition status, mitigate DRM impacts on health and performance outcomes, and/or risks to food safety, stability, and/or acceptability.

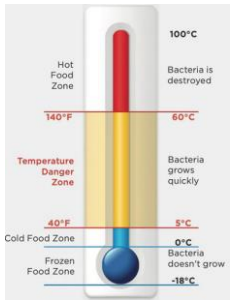
FN-301: Validate an integrated CM in flight.

https://humanresearchroadmap.nasa.gov/

Nutrition

Safety

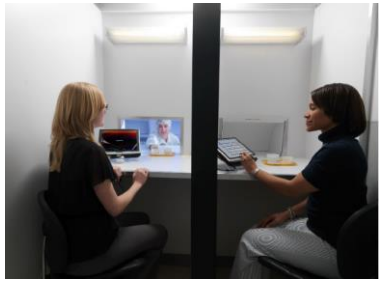
Prepackaged Foods: Crews are trained to discard uneaten food within 2 hrs of preparation



www.sperdirect.com

Crops: Crews are trained to use ProSan® citric acid wipes to sanitize produce for consumption

Acceptability



Grade	Score
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

HRP Food and Nutrition Risk Approach Plan

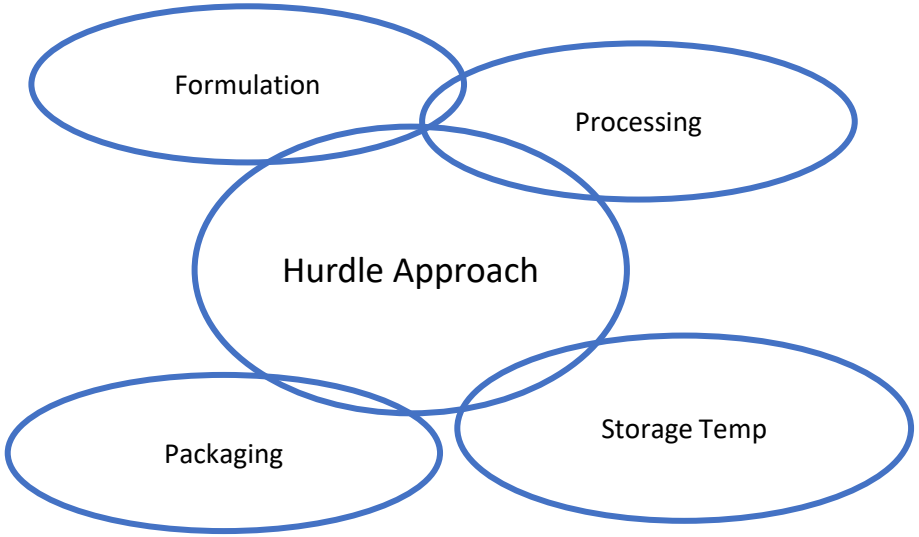
FN-101: Determine the nutritional requirements that would maintain health and performance for DRMs.

FN-102: Determine the nutrient content, safety, and acceptability of the spaceflight food system (specific to each DRM and associated vehicle constraints).

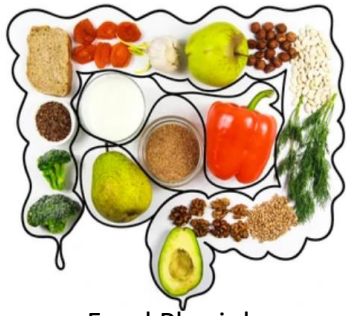
FN-201: Develop countermeasures either within the food system (i.e. variety, process improvements, crop growth, etc.) or in addition to (i.e. supplementation, etc.) to mitigate decrements in nutrition status, mitigate DRM impacts on health and performance outcomes, and/or risks to food safety, stability, and/or acceptability.

FN-301: Validate an integrated CM in flight.

https://humanresearchroadmap.nasa.gov/



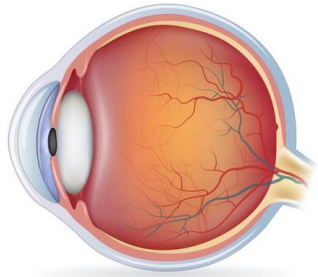
Partnerships in Crop Growth



Food Physiology

Immune System

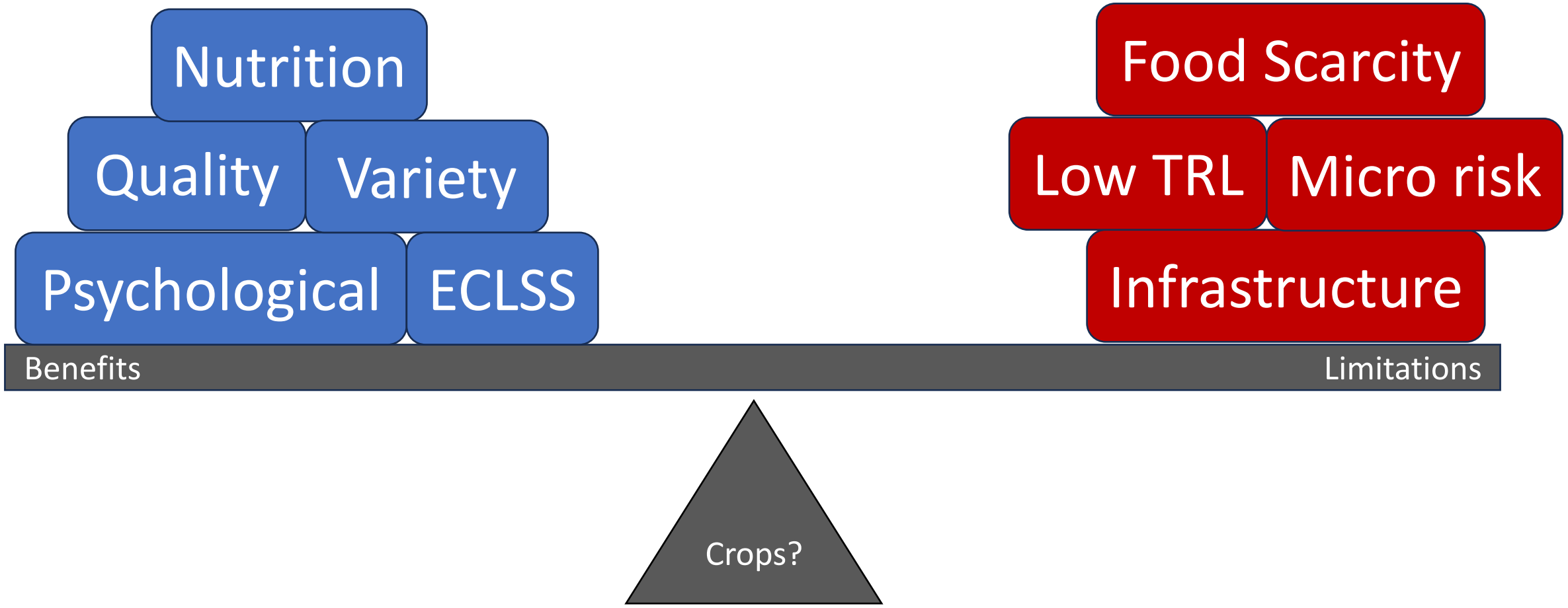
Palmer CM



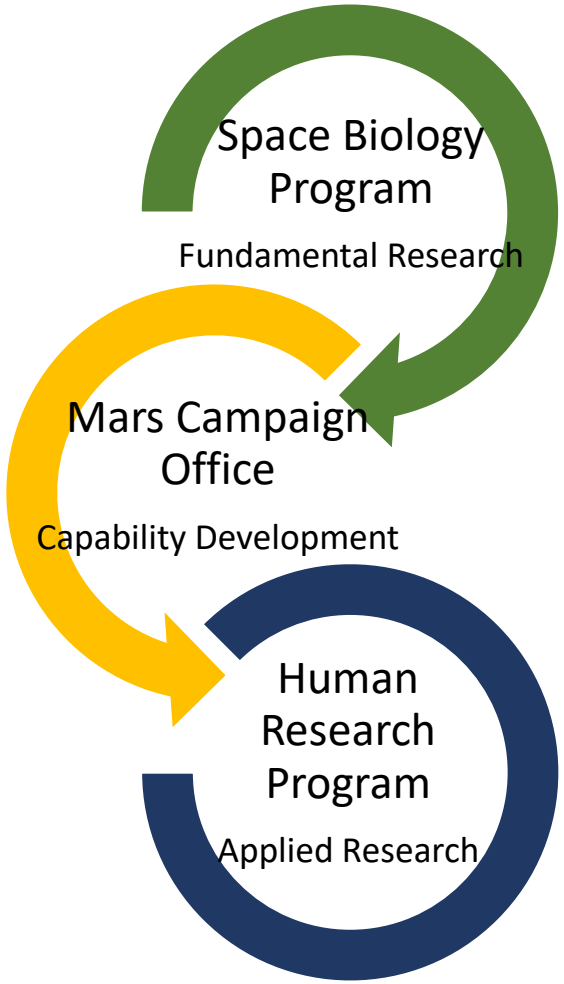
B Complex

Vit D

Crops? Benefits vs Limitations

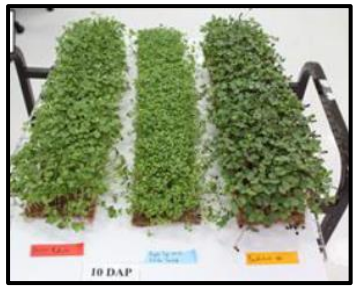


NASA Programs: Crop Growth



Terrestrial Testing


Legumes

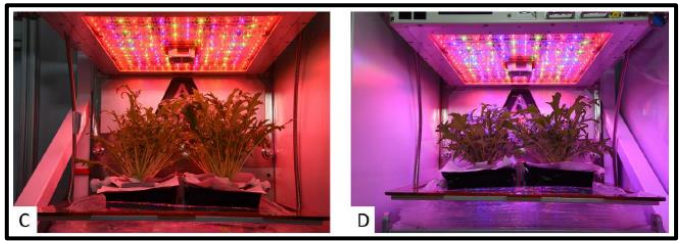


Microgreens


Seed Radiation

HRF VEG

VEG-04



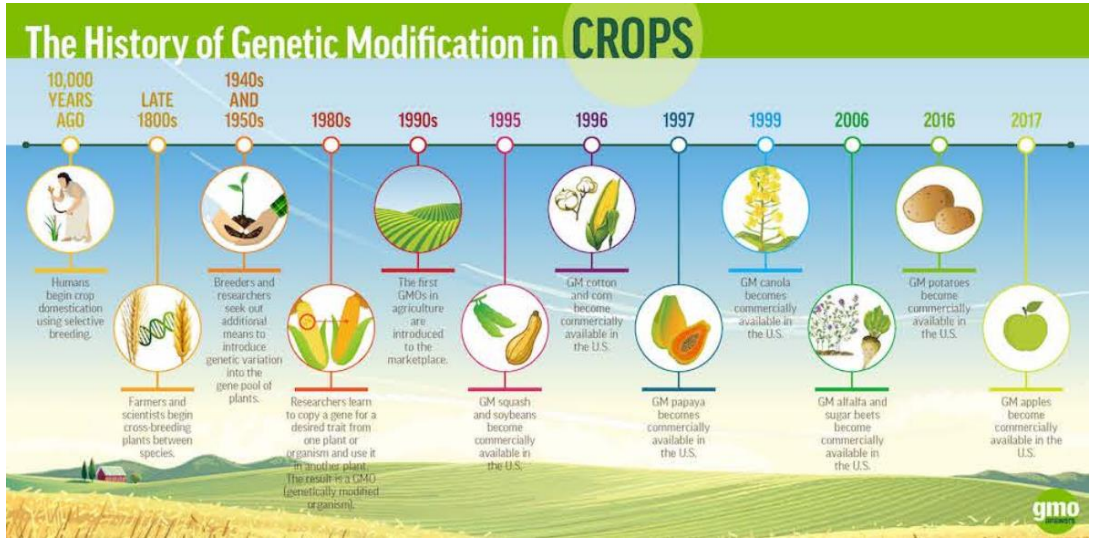
Mizuna mustard

VEG-05


'Red Robin' dwarf tomato

HRP Food Safety Research Focus

- NASA Spaceflight Standard 3001, Vol. 2 [Processed Foods]
  - $2x10^4$ CFU/g total aerobic count
  - 10^3 CFU/g yeasts and molds
  - 10^2 CFU/g coliform or coagulase-pos *Staphylococci*
  - No *Salmonella*
- Microbial limits for crops is forward work

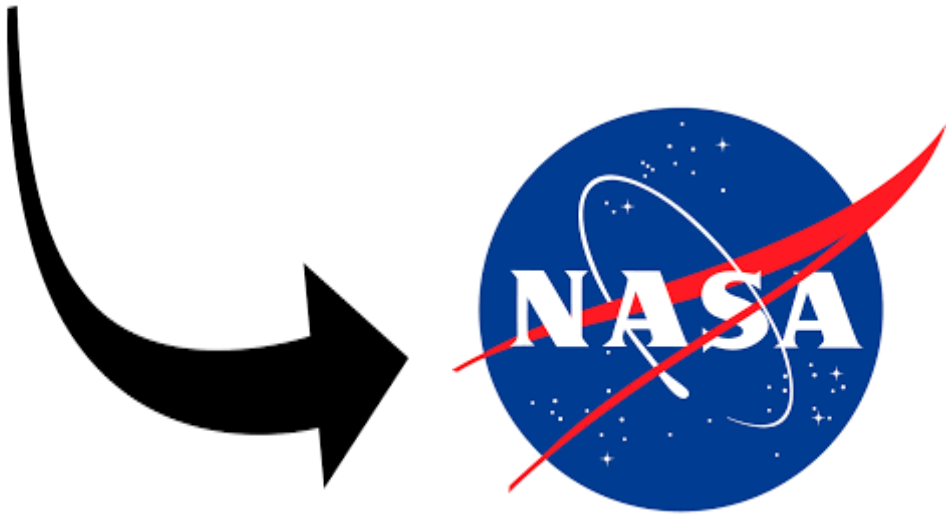


www.gmoanswers.com

Biotechnology Products

Coordinated Framework for Regulation of Biotechnology

The goal of the Coordinated Framework is to ensure public confidence in the regulatory system and improve transparency, predictability, Coordination, and efficiency of the biotechnology regulatory system.



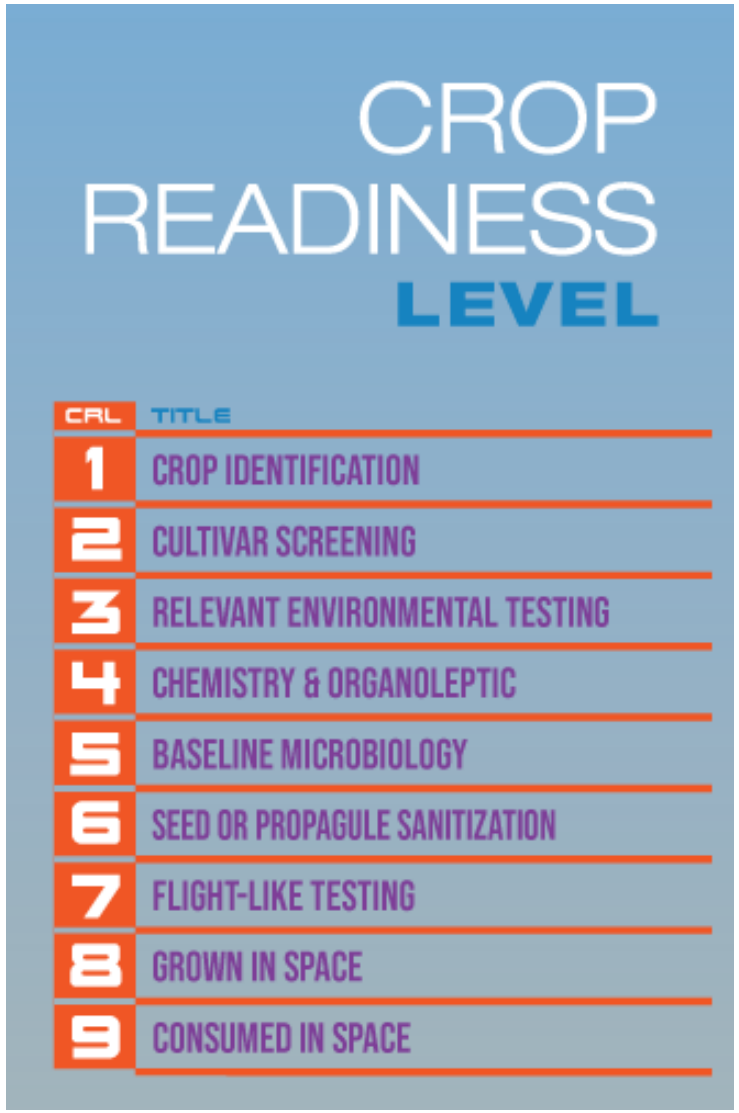
Initial FDA Consultation
Product, intended use, molecular characterization, safety assessment, nutrient/anti-nutrient/toxicant changes

Recommendations for scientific or regulatory issues to address

Final FDA Consultation

NASA IRB
Approval for research studies

NASA Crop Growth Status



		1	2	3	4	5	6	7	8	9
Leafy Greens	Pass	1	1	6	7					9
	Fail		2	2	4		3	1		
Peppers	Pass		14	2	6					1
	Fail		8	7				2		
Tomatoes	Pass				5	1				
	Fail			3					1	
Legumes	Pass			16	6					
	Fail				3					
Microgreens	Pass			19	8					
	Fail			1	3	35				
Herbs	Pass			13	8					
	Fail			3						
Misc	Pass			2			1			1
	Fail			1	3					

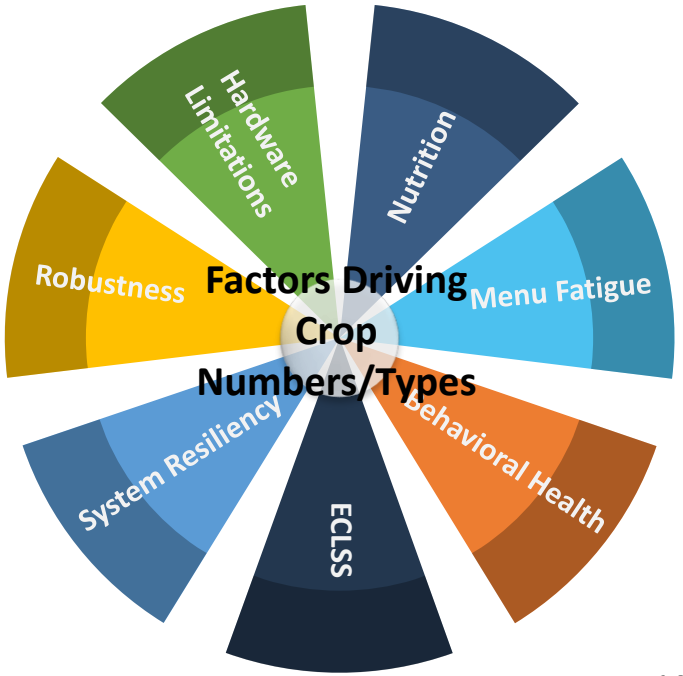
Space Crops White Paper, HRP, 2023

NASA Crop Growth Status

CROP READINESS LEVEL

CRL	TITLE
1	CROP IDENTIFICATION
2	CULTIVAR SCREENING
3	RELEVANT ENVIRONMENTAL TESTING
4	CHEMISTRY & ORGANOLEPTIC
5	BASELINE MICROBIOLOGY
6	SEED OR PROPAGULE SANITIZATION
7	FLIGHT-LIKE TESTING
8	GROWN IN SPACE
9	CONSUMED IN SPACE

		1	2	3	4	5	6	7	8	9
Leafy Greens	Pass	1	1	6	7					9
	Fail		2	2	4		3	1		
Peppers	Pass		14	2	6					1
	Fail		8	7				2		
Tomatoes	Pass				5	1				
	Fail			3					1	
Legumes	Pass			16	6					
	Fail				3					
Microgreens	Pass			19	8					
	Fail			1	3	35				
Herbs	Pass			13	8					
	Fail			3						
Misc	Pass			2						
	Fail			1	3					



Space Crops White Paper, HRP, 2023

National Aeronautics and Space Administration

Questions

Becky.Brocato@nasa.gov